

WHAT IS CLAIMED IS:

1 1. A method for processing signals in a pulse oximeter to determine
2 oxygen saturation and pulse rate, comprising:
3 receiving waveforms corresponding to two different wavelengths of light from
4 a patient;
5 ensemble averaging said waveforms in a first ensemble averager;
6 calculating a pulse rate based on an output of said first ensemble averager;
7 normalizing said waveforms to produce normalized waveforms;
8 ensemble averaging said normalized waveforms in a second ensemble
9 averager; and
10 calculating an oxygen saturation based on an output of said second ensemble
11 averager.

1 2. The method of claim 1 further comprising:
2 said ensemble averaging using variable weights;
3 selecting first metrics for said first ensemble averager to optimize said
4 calculating a pulse rate; and
5 selecting second metrics for said second ensemble averager to optimize said
6 calculating an oxygen saturation.

1 3. The method of claim 2 wherein said first and second metrics both
2 include an arrhythmia metric for detecting an arrhythmic pulse, said arrhythmia metric for
3 said first metrics, in connection with calculating a pulse rate, having a lower associated
4 threshold for recognizing arrhythmia than said arrhythmic metric for said second metrics.

1 4. The method of claim 2 wherein said first and second metrics both
2 include a short term metric which is a measure of short-term changes in pulse amplitude;
3 said first ensemble averager increasing an ensemble averaging weight in
4 response to a short-term decrease in pulse amplitude faster than said second ensemble
5 averager.

1 5. A pulse oximeter for determining oxygen saturation and pulse rate,
2 comprising:
3 a detector which receives waveforms corresponding to two different
4 wavelengths of light from a patient;

5 a first ensemble averager;
6 a pulse rate calculator, coupled to an output of said first ensemble averager;
7 a normalizer coupled to said detector for normalizing said waveforms to
8 produce normalized waveforms;
9 a second ensemble averager; and
10 an oxygen saturation calculator coupled to an output of said second ensemble
11 averager.

1 6. The pulse oximeter of claim 5 further comprising:
2 wherein said ensemble averagers are configured to ensemble average using
3 variable weights;
4 a signal quality metric calculator configured to provide first metrics for said
5 first ensemble averager to optimize said calculating a pulse rate, and second metrics for said
6 second ensemble averager to optimize said calculating an oxygen saturation.

1 7. A method for processing signals in a pulse oximeter to determine
2 oxygen saturation and pulse rate, comprising:
3 receiving waveforms corresponding to two different wavelengths of light from
4 a patient;
5 low pass filtering said waveforms in a first low pass filter;
6 calculating a pulse rate based on an output of said first low pass filter;
7 normalizing said waveforms to produce normalized waveforms;
8 low pass filtering said normalized waveforms in a second low pass filter; and
9 calculating an oxygen saturation based on an output of said second low pass
10 filter.

1 8. The method of claim 7 further comprising:
2 selecting first metrics for said first low pass filter to optimize said calculating
3 a pulse rate; and
4 selecting second metrics for said second low pass filter to optimize said
5 calculating an oxygen saturation.

1 9. The method of claim 8 wherein:
2 the low-pass filtering weight associated with said first low pass filter is based
3 on a frequency ratio metric which quantifies the frequency-content of said waveforms relative
4 to a pulse-rate estimate.

1 10. The method of claim 8 wherein:
2 a low-pass filtering weight for said second low pass filter is based on
3 a frequency ratio metric which quantifies the frequency-content of said
4 waveforms relative to a pulse-rate estimate that metric, and
5 a separate Ratio-of-Ratios variance metric.

1 11. A method for processing signals in a pulse oximeter to determine
2 oxygen saturation and pulse rate, comprising:
3 receiving waveforms corresponding to two different wavelengths of light from
4 a patient;
5 low pass filtering and ensemble averaging said waveforms in a first low pass
6 filter and ensemble averager;
7 calculating a pulse rate based on an output of said first low pass filter and
8 ensemble averager;
9 normalizing said waveforms to produce normalized waveforms;
10 low pass filtering and ensemble averaging said normalized waveforms in a
11 second low pass filter and ensemble averager; and
12 calculating an oxygen saturation based on an output of said second low pass
13 filter and ensemble averager.

1 12. A pulse oximeter for determining oxygen saturation and pulse rate,
2 comprising:
3 a detector which receives waveforms corresponding to two different
4 wavelengths of light from a patient;
5 a first low pass filtering;
6 a pulse rate calculator, coupled to an output of said first low pass filter;
7 a normalizer coupled to said detector for normalizing said waveforms to
8 produce normalized waveforms;
9 a second low pass filter; and

10 an oxygen saturation calculator coupled to an output of said second low pass
11 filter.

1 13. The pulse oximeter of claim 12 further comprising:
2 wherein said low pass filters are configured to ensemble average using
3 variable weights;
4 a signal quality metric calculator configured to provide first metrics for said
5 first low pass filter to optimize said calculating a pulse rate, and second metrics for said
6 second low pass filter to optimize said calculating an oxygen saturation.

1 14. The pulse oximeter of claim 12 wherein:
2 the low-pass filtering weight associated with said first low pass filter is based
3 on a frequency ratio metric which which quantifies the frequency-content of said waveforms
4 relative to a pulse-rate estimate.

1 15. The pulse oximeter of claim 12 wherein:
2 a low-pass filtering weight for said second low pass filter is based on
3 a frequency ratio metric which which quantifies the frequency-content of said
4 waveforms relative to a pulse-rate estimate that metric, and
5 a separate Ratio-of-Ratios variance metric.

1 16. A pulse oximeter for determining oxygen saturation and pulse rate,
2 comprising:
3 a detector which receives waveforms corresponding to two different
4 wavelengths of light from a patient;
5 a first low pass filtering and ensemble averager;
6 a pulse rate calculator, coupled to an output of said first low pass filter and
7 ensemble averager;
8 a normalizer coupled to said detector for normalizing said waveforms to
9 produce normalized waveforms;
10 a second low pass filter and ensemble averager; and
11 an oxygen saturation calculator coupled to an output of said second low pass
12 filter and ensemble averager.

1 17. A method for processing signals in a pulse oximeter to determine
2 oxygen saturation, comprising:

3 receiving waveforms corresponding to two different wavelengths of light from
4 a patient;
5 processing a new waveform after a pulse period trigger to ensemble average
6 with a historical average waveform; and
7 when said new waveform differs from said historical average waveform by
8 more than a predetermined threshold, interpolating between the new waveform and the
9 historical average waveform for a first few samples of a new, composite historical average
10 waveform.

1 18. The method of claim 17 wherein said first few samples are four
2 samples, and said interpolations are at 80%, 60%, 40%, and 20% of the difference between
3 the new waveform and the historical average waveform.